



evfiresafe.com

EV FireSafe

Enhancing safety for emergency responders at **electric vehicle** fires

Emma Sutcliffe, Project Director
Dan Fish, Technical Specialist

EVs & Emergency Response

Supported by:



Australian Government
Department of Defence

In partnership with:





We're researching

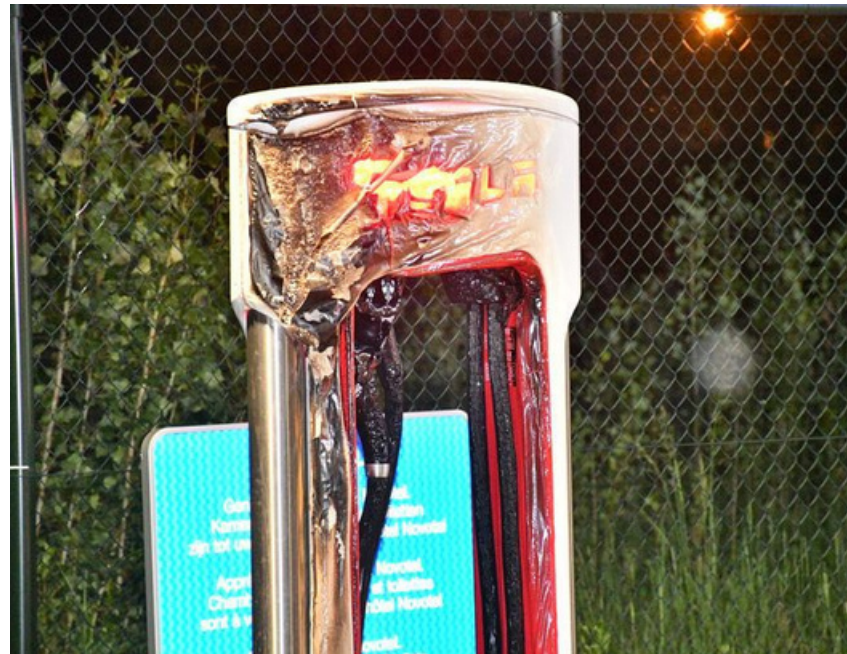
EV lithium ion battery fires

What do they mean for emergency responders?

+

connection to energised charging

What additional risks do emergency responders face?



NEW EV LiB FOR INVESTIGATION

2 November, 2022 - Klosterneuburg, Germany

☰ 1

bmw ix i4 fires

15 June, 2022 - Laos



BYD Song, 15 October 2022, China

☰ 4

VERIFIED Passenger EV LiB FIRES (added to database)



1 May, 2012 - Fort Bend County, Texas, USA

☰ 2 3



26 May, 2012 - Shenzhen, China

☰ 1 1

Workshop / repair EV LiB Fires



NEW INCIDENT
2 March, 2019 - Surrey, England (Tesla Service Centre)

☰ 3 2



NEW INCIDENT
27 August, 2021 - Bonnevoie, Luxembourg (Tesla service centre)

☰ 3 7



e-B



25 J

16 M
Chir



27 S
Cou





01 - Home

02 - What is EV FireSafe?

03 - Electric vehicles

04 - EV fires

05 - EVFS info & resources

06 - EVFS

EV FireSafe



Enhancing safety for emergency responders at *electric vehicle* traction battery fires

→ Welcome! Start here...

EV FireSafe is proudly supported by:



Australian Government
Department of Defence

With assistance from:

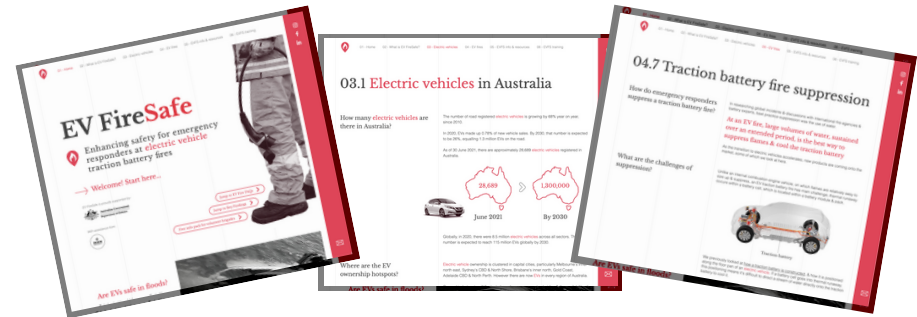


EV FireSafe's global work

Research funded by:



Australian Government
Department of Defence



Our work is referenced by &/or we collaborate with:



NFCC
National Fire Chiefs Council



Nederlands
Instituut
Publieke
Veiligheid



We are invited Technical Panel members for Fire Protection Research Foundation's (at the National Fire Protection Association, US), 2 year testing & training program:

"Assessment of Electric Vehicle Firefighting Techniques, Technologies & the Impact of Stranded Energy"





ACT Fire Rescue's brand new e-truck



What does our data say?

(And does the FUD match?)

EV fires are ~~big news~~ clickbait

The screenshot shows a YouTube search for "electric car fires". The search results are as follows:

- burning electric car - Vetter EIS System**
Permanent extinguishing and compact storage of electric vehicles with lithium-ion battery. System for cooling and safe storage of...
Ad · <https://www.vetter.de/>
- Firefighters warn of 'enormous' EV fire consequences | ABC News**
32K views · 2 months ago
ABC News (Australia)
Subscribe: <http://ab.co/1svxLVE> Read more here: <https://ab.co/3FErWnZ> They say electric vehicle fires pose a number of risks, not ...
- THE FACTS ABOUT EV FIRES**
29K views · 1 month ago
Electric Classic Cars
If you believe the media sometimes you'd think that the slightest accident in an EV would turn into a fireball or people shouldn't ...
4K
- Why Tesla Fires are Impossible to Put Out**
1.6M views · 6 months ago
Donut
What really happens when an electric car catches on fire? And does your fire department know how to put these raging infernos ...
4K

The video "Why Tesla Fires are Impossible to Put Out" is circled in red.

= 1.6m views

EV fires are ~~big news~~ clickbait

Misleading, unresearched information = 45k views



EV fires - rescuers and the public are unprepared against the risks | Auto Expert John Cadogan



Auto Expert John Cadogan
342K subscribers

Subscribe

2.6K



Share

Thanks

Clip

Save



EV fires are ~~big news~~ clickbait

Widely reported statements by
Firefighters Union ACT President

Mr McConville also said that the problem was not limited to EVs.

"Many homes are installing lithium batteries as part of their solar panel energy systems and BESS are being installed in underground car parks and in apartment blocks," he said.

Mr McConville added that thermal runaway fires released toxins which were dangerous to firefighters and the community.

"BESS fires release an array of deadly toxins including Carbon Monoxide, Hydrogen Cyanide, Hydrogen Fluoride and Cobalt," he said.

"These toxins are especially dangerous to firefighters because they are dermally absorbed through the skin and no personal protective clothing can protect you against it.

Carbon Monoxide and Hydrogen Cyanide are known as the terrible twins. They prevent the body using oxygen and cyanide affects organs that rely on high levels of oxygen such as the heart and the brain.

"We've already had a situation in Victoria where two firefighters suffered Cobalt poisoning after attending an EV fire, and have now been permanently disabled as a result.

These toxins also present a major risk to other emergency services personnel such as police and ambulance officers, bystanders and the broader community and as such, every possible measure must be undertaken to reduce their impact."

Mr McConville said that the increasing uptake of EV and BESS units meant Australia's governments needed to develop regulation, policy, training and education to cut risks.

*Incorrect &
misleading*

Incorrect

EV fires - rescuers and the public are un



Auto Expert John Cadogan
342K subscribers

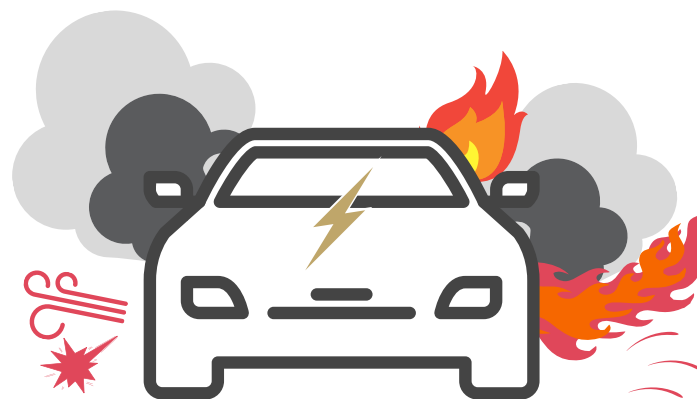
Subscri

EV LiB fires are very rare

In passenger plug-in EVs, we have verified*:

387 EV traction battery fires globally, 2010-today

+ 74 currently being cross checked



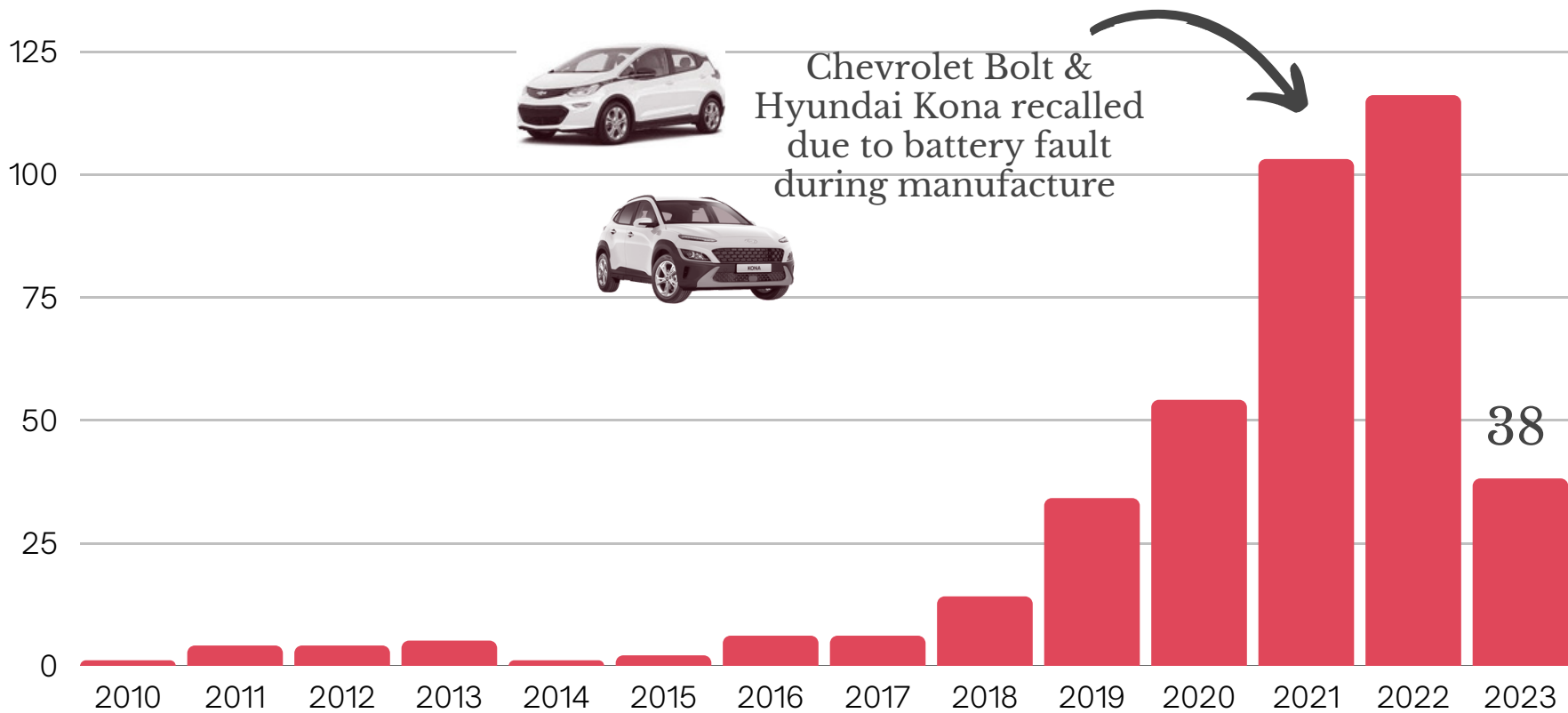
'In the world of clean energy, few areas are as dynamic as the electric car market. We estimate there are now **around 16 million electric cars** on the road worldwide...'

International Energy Agency, January 2022

7.8 million EVs were sold in 2022 alone...

Wall Street Journal, January 2023

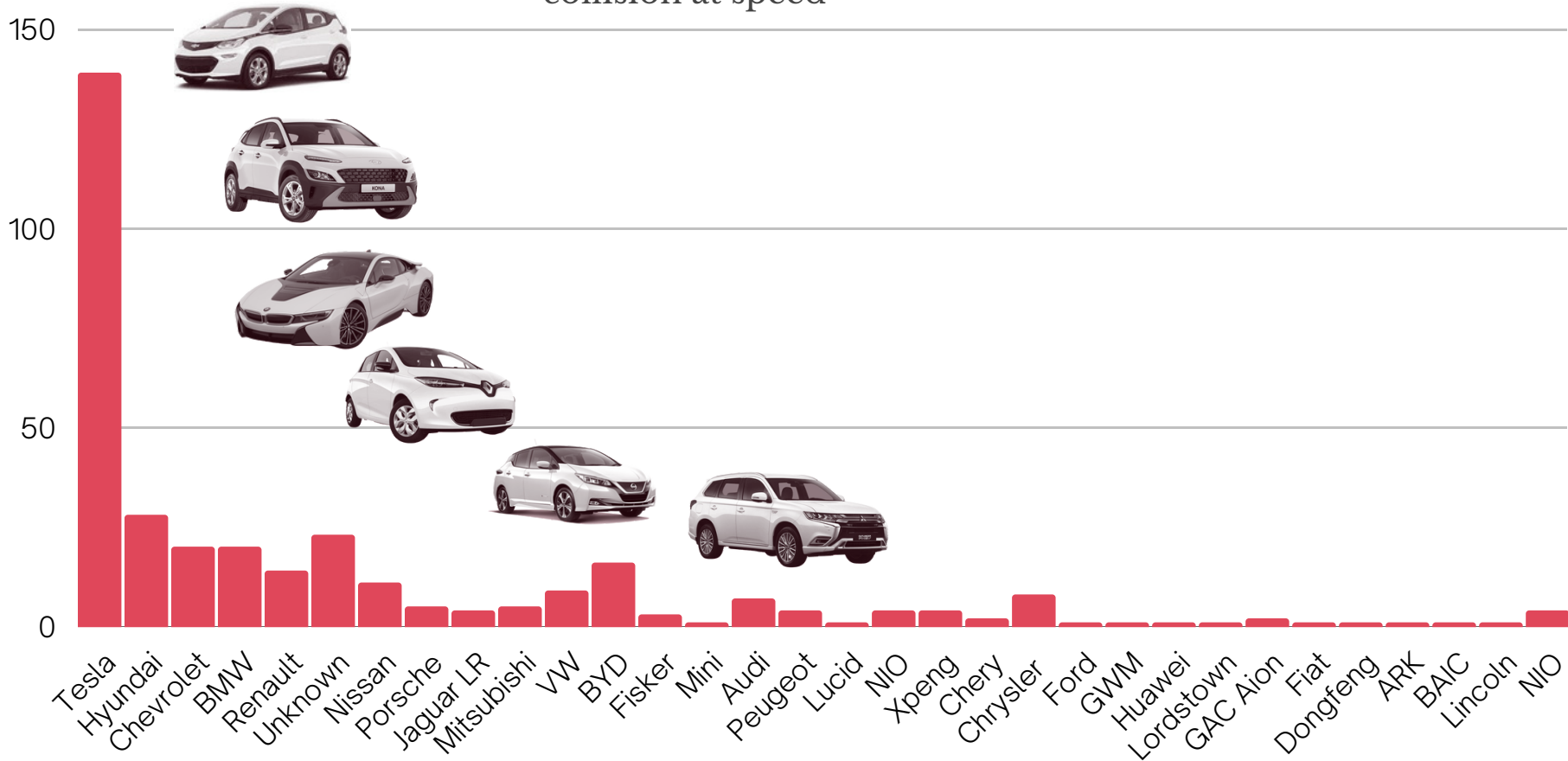
EV fires by year



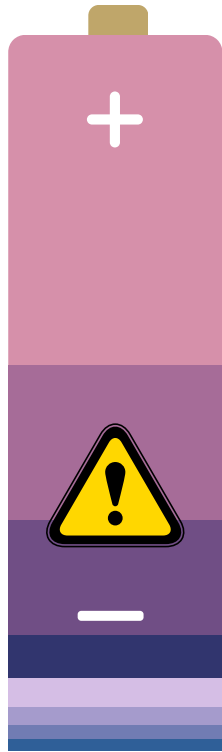
EV fires by manufacturer



Most number of EVs
on the road
Most number of
'collision at speed'



Causes of battery cell abuse



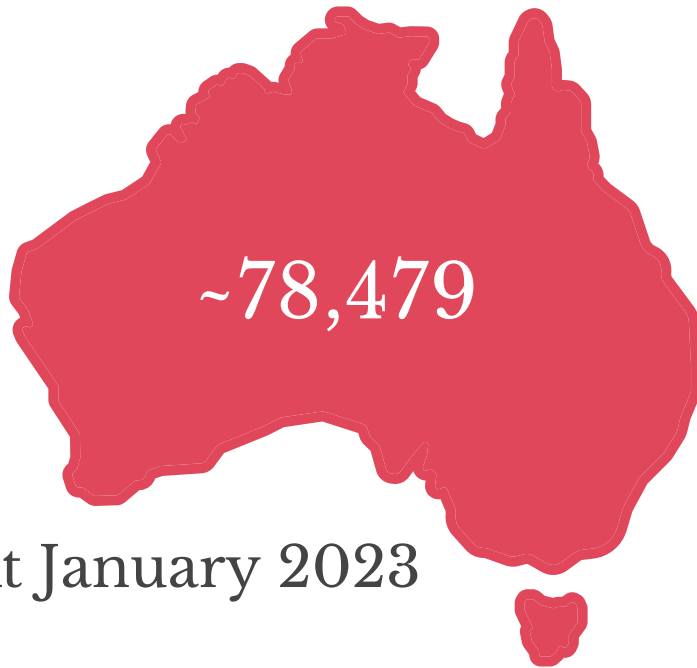
Unknown	49%
Collision / debris	22%
OEM fault	12%
Submersion	6%
Arson / malicious	3%
External fire	3%
Repair / workshop	2%
Overheating / electrical	2%
Manufacturing defect	0.5%
Human error	0.5%

*Data current January 2023

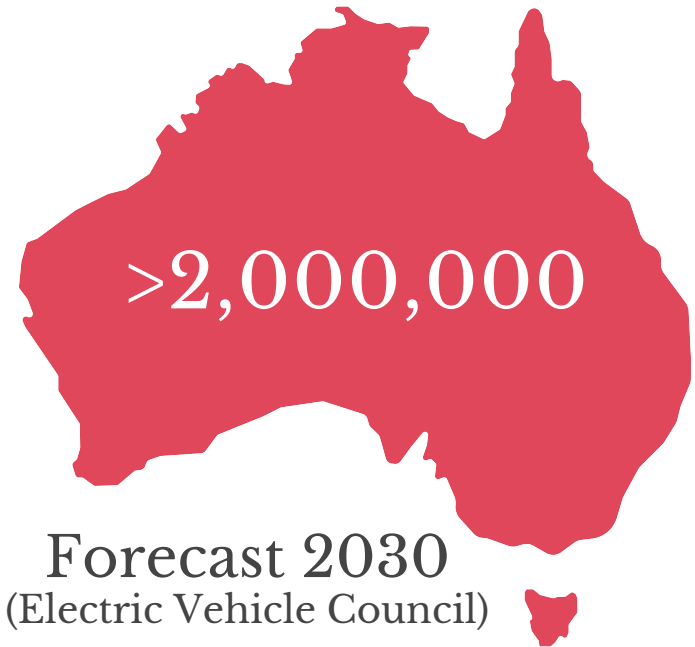
^Percentage of incidents EVFS studied

EVs in Australia

EV ownership* is concentrated in capital & major cities, but there are now EVs in every Australian region



At January 2023

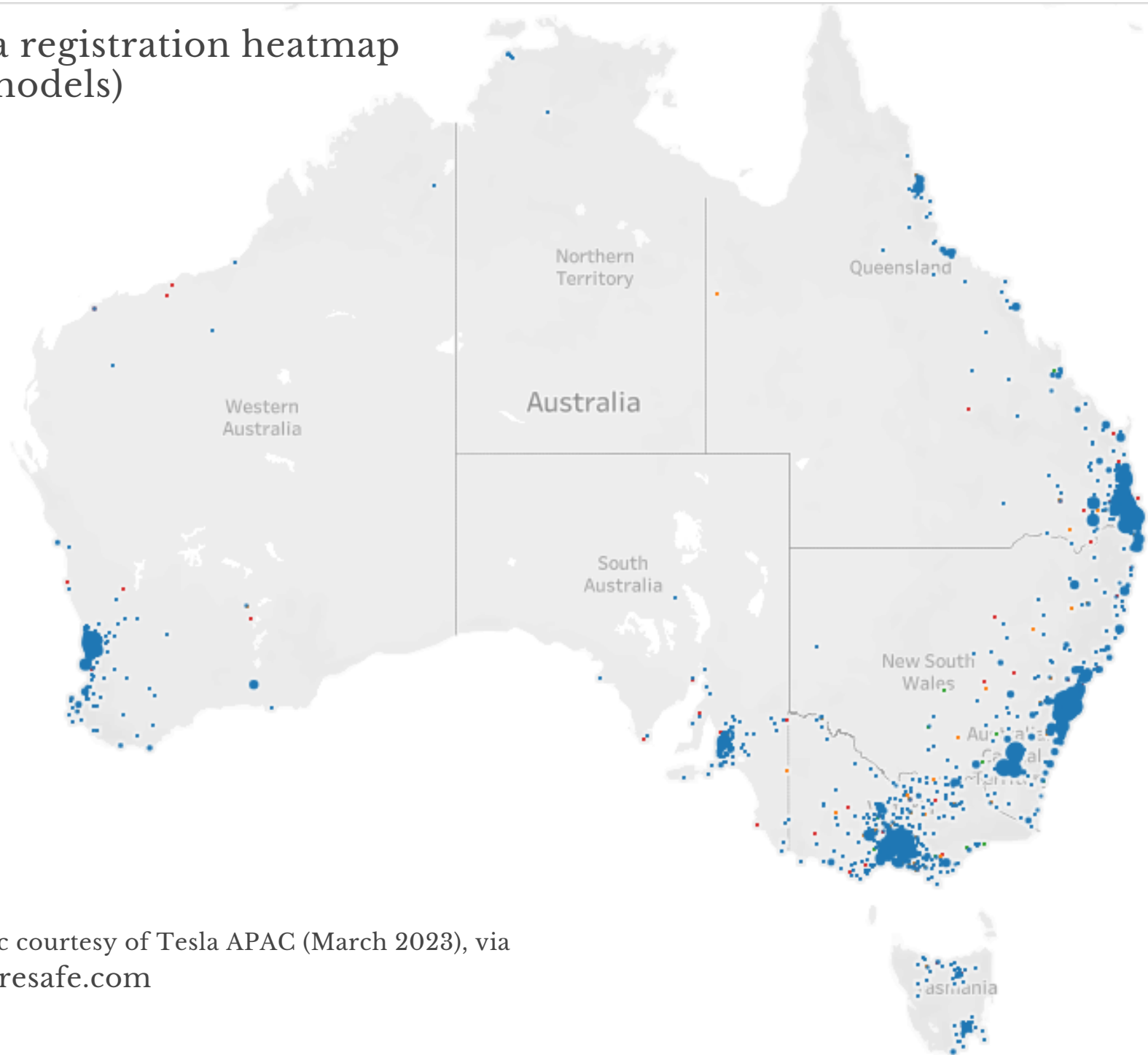


Forecast 2030
(Electric Vehicle Council)

~70%

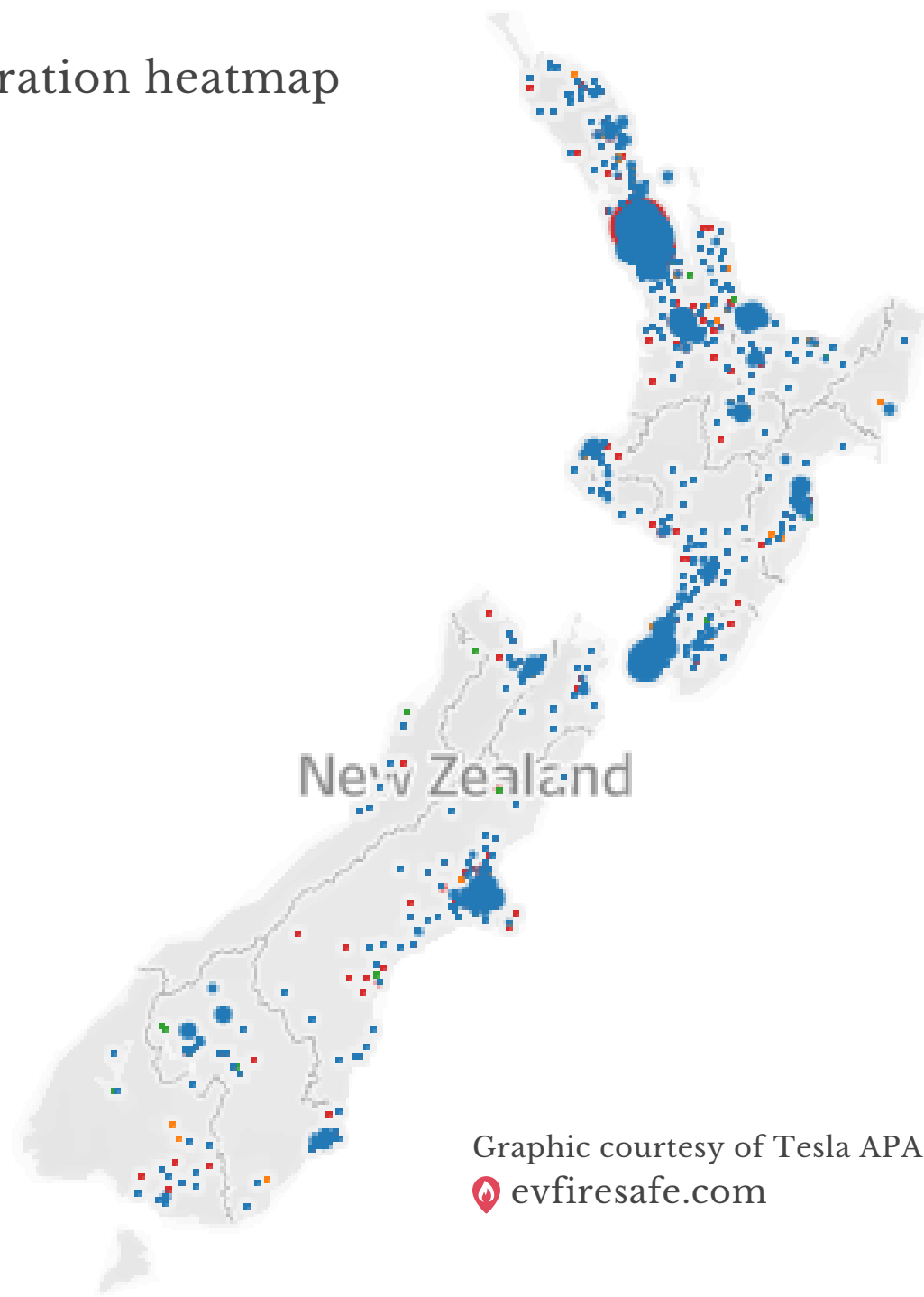
compound annual growth
rate of EVs since 2010

Tesla registration heatmap (all models)



Graphic courtesy of Tesla APAC (March 2023), via
 [evfiresafe.com](https://www.evfiresafe.com)

Tesla registration heatmap (all models)



Graphic courtesy of Tesla APAC (March 2023), via  evfiresafe.com

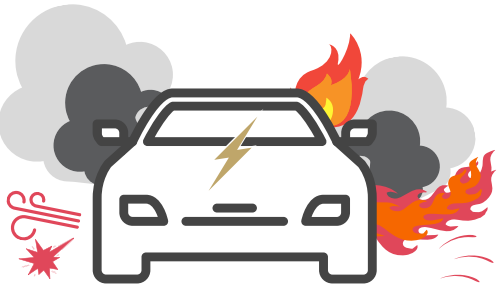


What about other EV types?

From 1st Jan 23, we started tracking
BEB, BET & LEV

EV comparison for Q1 2023

Passenger EVs



23

Battery fires

8

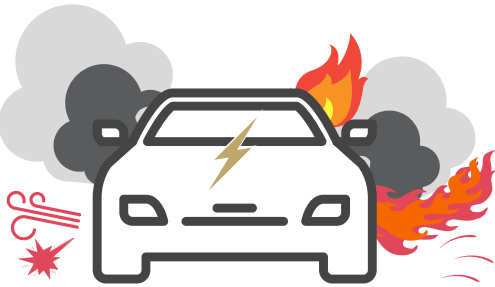
Injuries

4

Fatalities

EV comparison for Q1 2023

Passenger EVs



23

Battery fires

8

Injuries

4

Fatalities

Electric buses & trucks



2

Battery fires

1

Battery fire

0

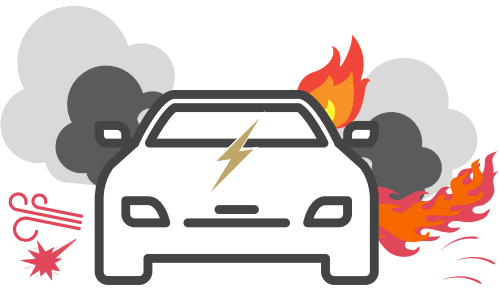
Injuries

0

Fatalities

EV comparison for Q1&2 2023

Passenger EVs



35

Battery fires

8

Injuries

4

Fatalities

Electric buses & trucks



2

Battery fires

1

Battery fire

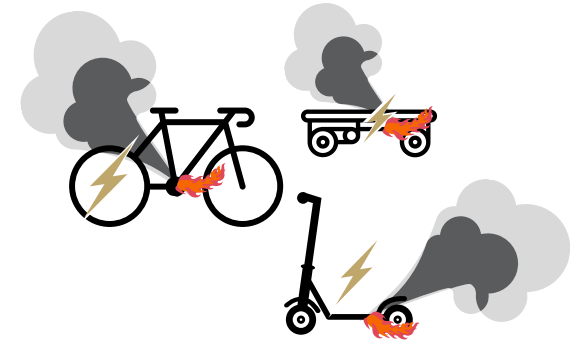
0

Injuries

0

Fatalities

Light electric vehicles



64

Battery fires

62

Injuries

21

Fatalities



29 17:31:37

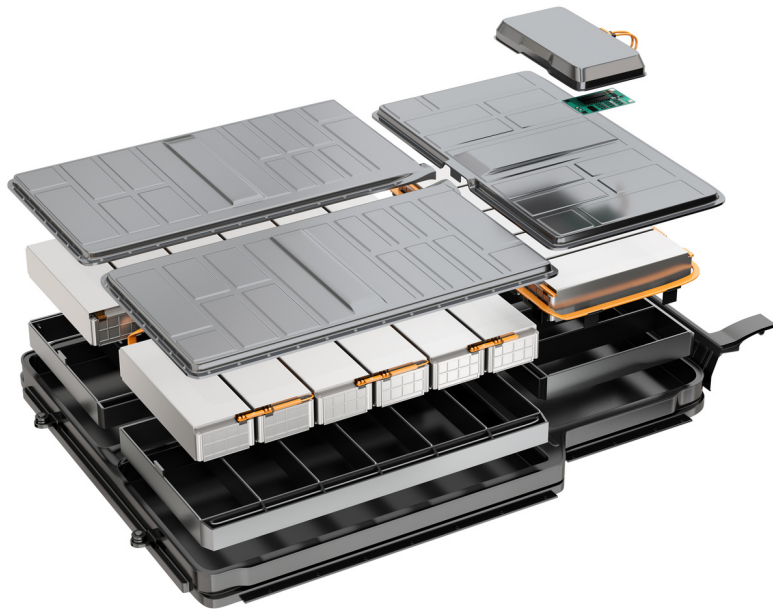
New risks & challenges

What do emergency responders know - & need to learn - to face EV ignition, vapour cloud explosion, electrocution & collision risks?



Two concepts

Battery pack
construction



Thermal
runaway

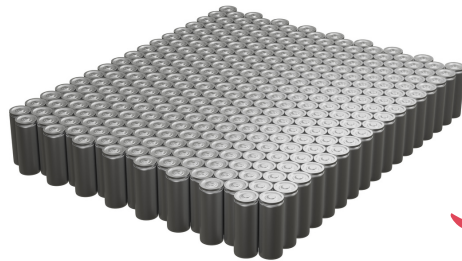


Battery pack construction

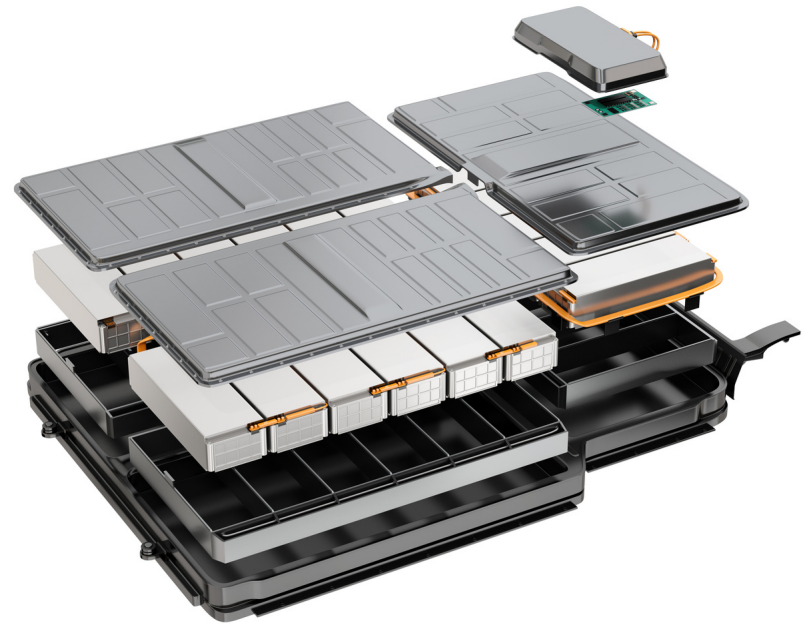
An EV HV traction battery pack is typically constructed like this:



Lithium ion
battery cell



Multiple cells make a
battery module

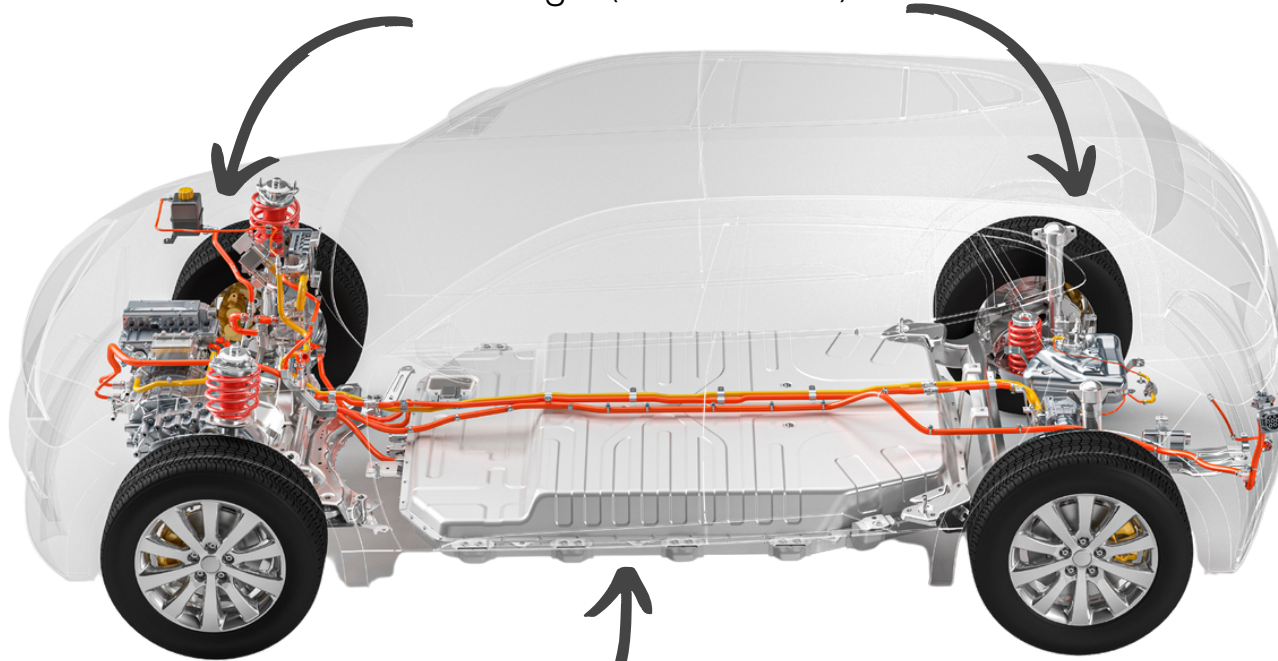


Multiple modules
make a battery pack,
which is enclosed in
protective battery
casings

Battery pack construction

In passenger EVs, the traction battery supplies power for vehicle momentum & is located beneath the vehicle, along the floor pan

Orange cables & components indicate high voltage (above 60V)

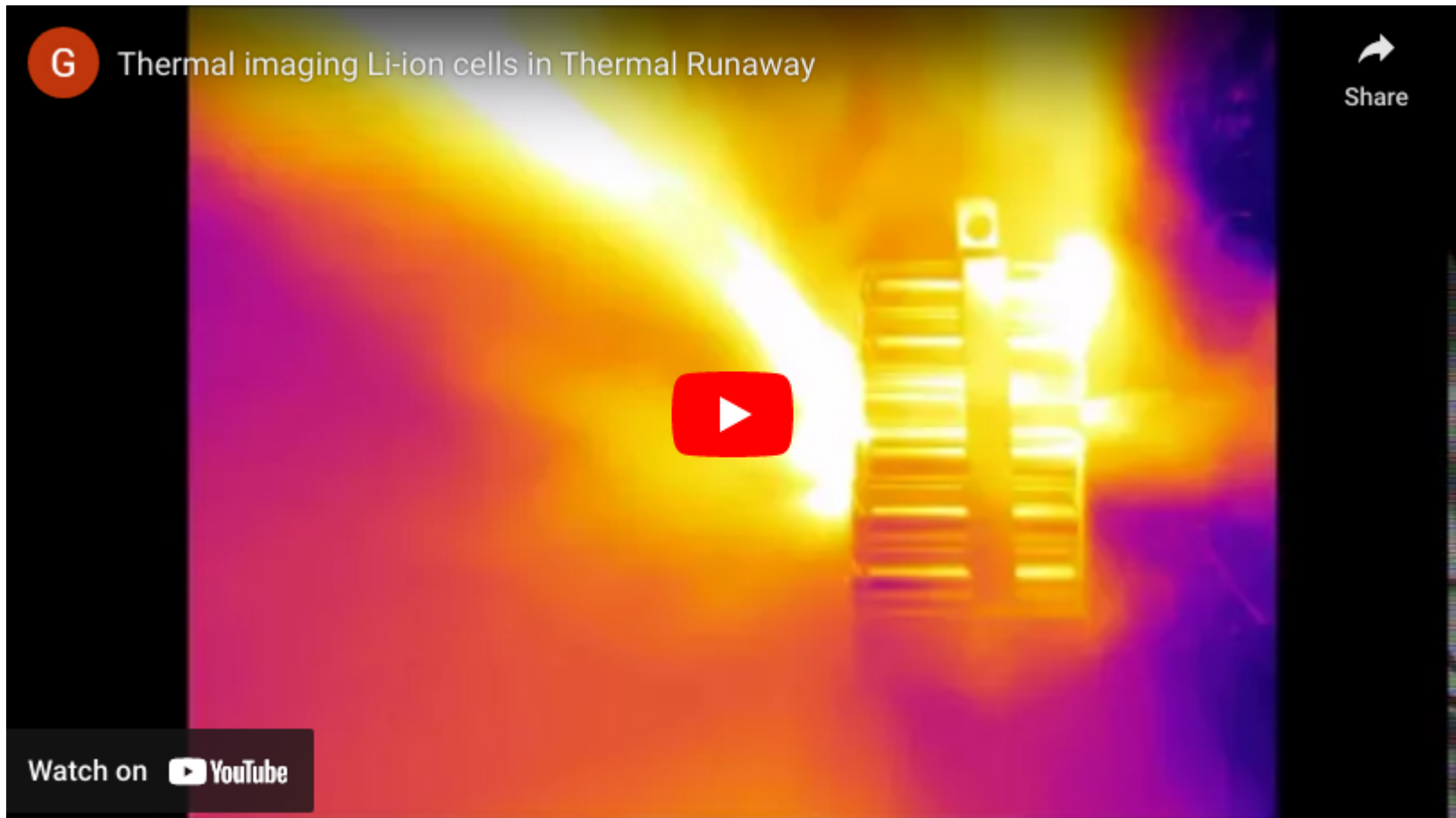


EV traction battery pack



Thermal runaway

An **unstable chemical process** that is difficult to bring under control.

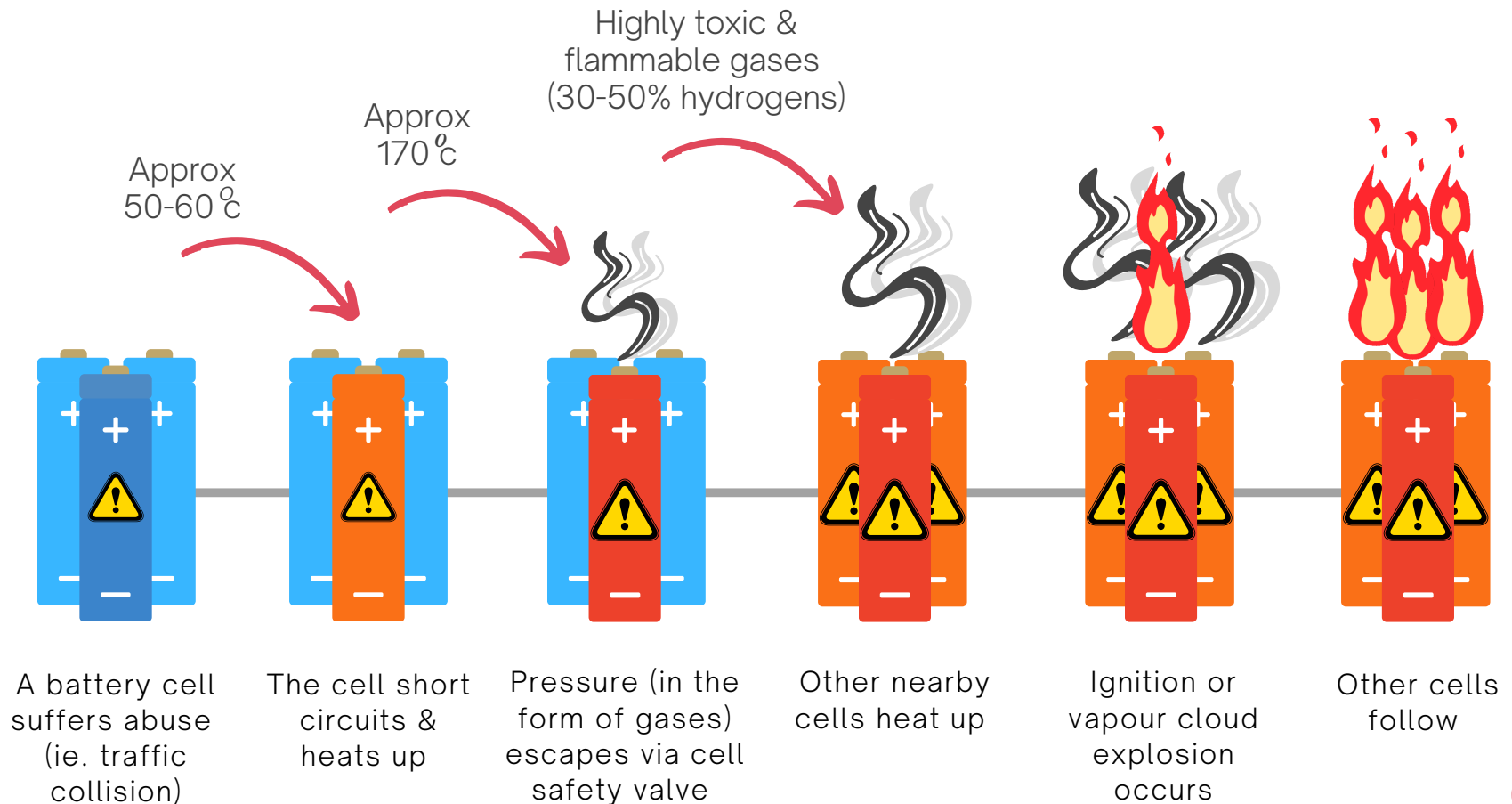


[Click to view video on evfiresafe.com/ev-fire-what-is-thermal-runaway.](https://evfiresafe.com/ev-fire-what-is-thermal-runaway)



Thermal runaway

Thermal runaway occurs when a battery cell suffers abuse, short circuits, heats up & bursts.



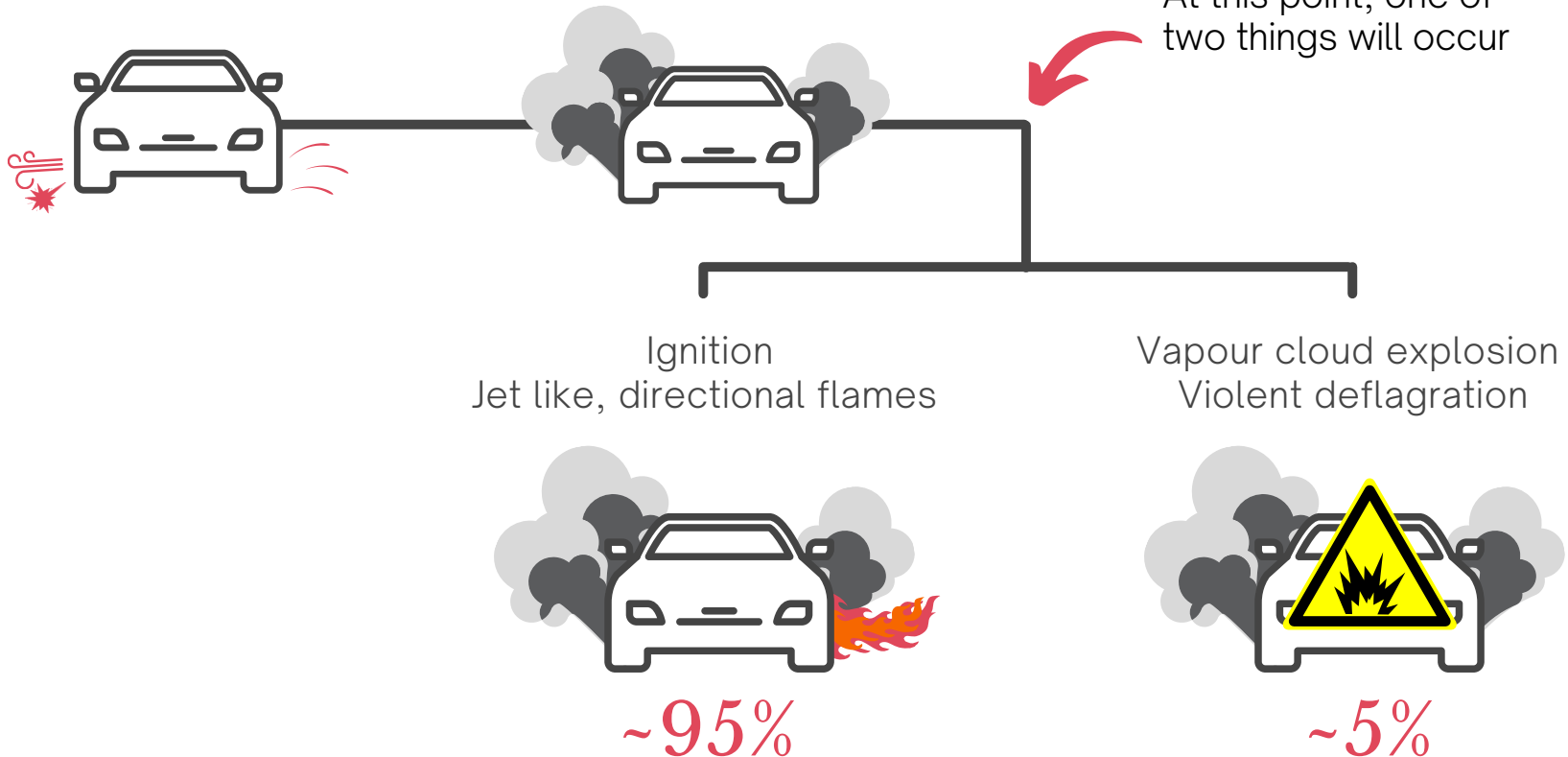
Early warning signs

From an emergency responder perspective, thermal runaway looks & sounds like this

Popping - gunshots
Hiss/whistle - gas venting
'Cherry bubblegum' smell
Projectiles - cell debris

Dark vapour cloud,
light vapour cloud
(it's NOT smoke)

At this point, one of
two things will occur





[Click to view video on https://www.evfiresafe.com/ev-fire-behaviour](https://www.evfiresafe.com/ev-fire-behaviour)



Vapour cloud explosion

Total of 20 **VCE incidents** globally since 2010:

70%

Underground /
enclosed space



30%

Open air



4 incidents verified of:

- vapour cloud explosion
- in an enclosed space
- while connected to energised charging



Vapour cloud explosion



Click to view video on <https://www.evfiresafe.com/post/electric-car-explosions>

Vapour cloud explosion



[Click to view video on https://www.evfiresafe.com/post/electric-car-explosions](https://www.evfiresafe.com/post/electric-car-explosions)



What is the RotW doing?

We went to Norway, Netherlands, Germany & the UK to find & share knowledge

European conferences

Listening to & meeting with the world's leading scientists, researchers, firefighters & SMEs



- Battery Tech Expo
- London Fire Brigade
- National Fire Chief's Council



- Fires in Vehicles Conference
- International Symposium on Tunnel Safety & Security
- Nordic EV Expo
- Rogaland Fire Brigade



- Institute of Public Safety (NIPV)
- Schipol International Airport Fire Brigade
- DAF Trucks manufacturing plant
- Elaad NL
- Bussum Fire Brigade
- NL Towing Association



- Allianz Global Automotive Centre of Excellence
- Stellantis - Opel Manufacturing Plant
- Electromobility Safety Conference

What we learned...



No or limited testing & research



Some testing & research providing early answers, but more needed



Good results emerging, more to come



Testing done, answers widely accepted by SMEs & FR agencies



- Fire cause
- Risks & hazards (Incl vapour cloud explosion)
- Suppression
- Tools & products



- Efficacy of PPE/PPC
- Decon of PPE/PPC
- Electrocution risk



- Impact on structures
- Impact in enclosed spaces



- Air quality
- Water runoff contamination



- Enhanced safety around charging hubs
- Early detection
- Electrocution risk



- EVs & LiBs at sea
- Remote area management
- Car stacker systems



EV battery fire suppression

EV fire suppression

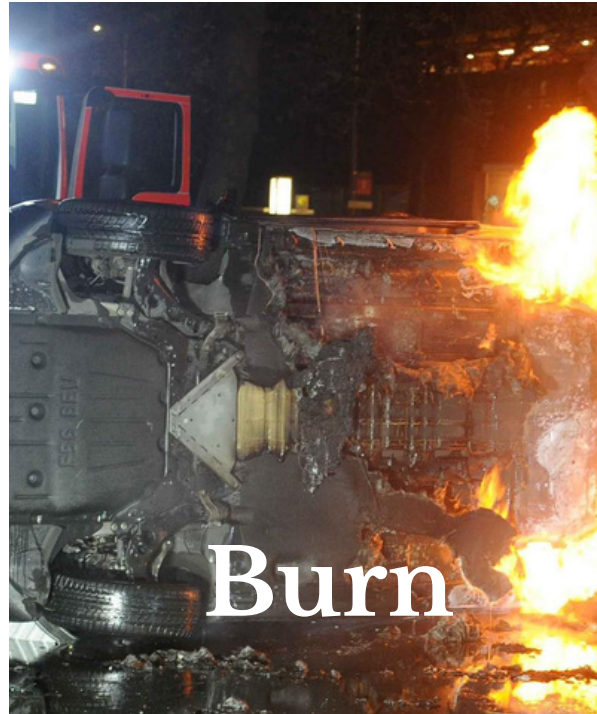
Three best practice options in use globally



Cool

Recommended by all EV manufacturers

Like 'putting out a kitchen fire by spraying water on the roof'



Burn

Accepted by some EV manufacturers

Removes stranded energy & secondary ignition risk



Submerge

Accepted by some EV manufacturers

Cools battery, contains fire spread, must be left >10 days

The Netherlands

Following difficult incidents like this, the Dutch use containers for effective carriage of totally destroyed EVs.



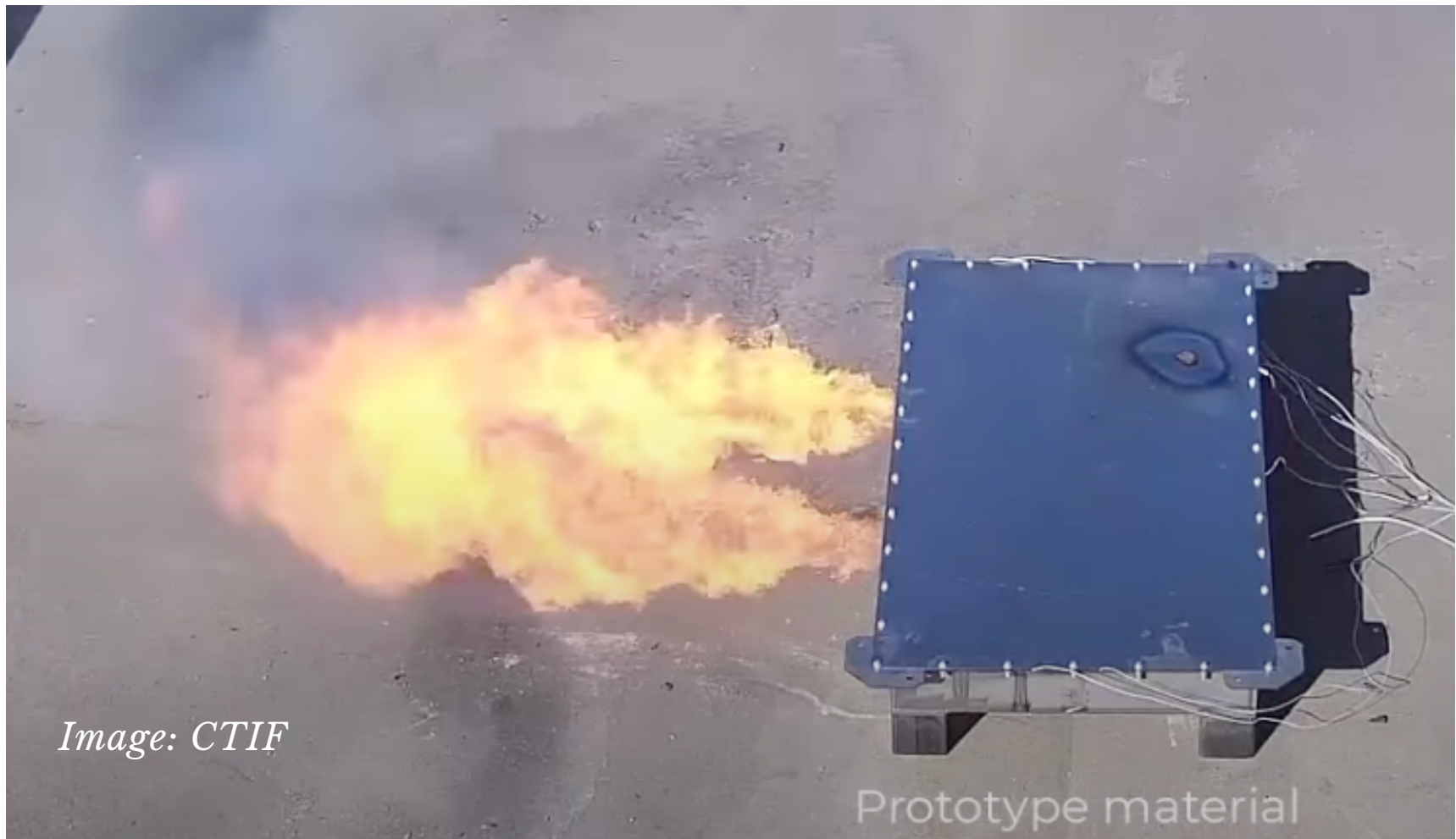
Submersion case study

- A BMW EV was suspected of thermal runaway & submerged insitu
- The container stood for 8 days in a residential neighbourhood
- 7,500 litres of polluted water had to be disposed of at a cost of ~AU\$52,500



Cutting

We've always known that getting water into a battery pack can manage a battery fire quickly, but recent Swedish tests have proven that.



Cutting into EV battery packs

We've always known that getting water into a battery pack can manage a battery fire quickly, Swedish tests have proven that.



Cutting into EV battery packs

We - & many others - won't recommend cutting because:

Increased risk to responders

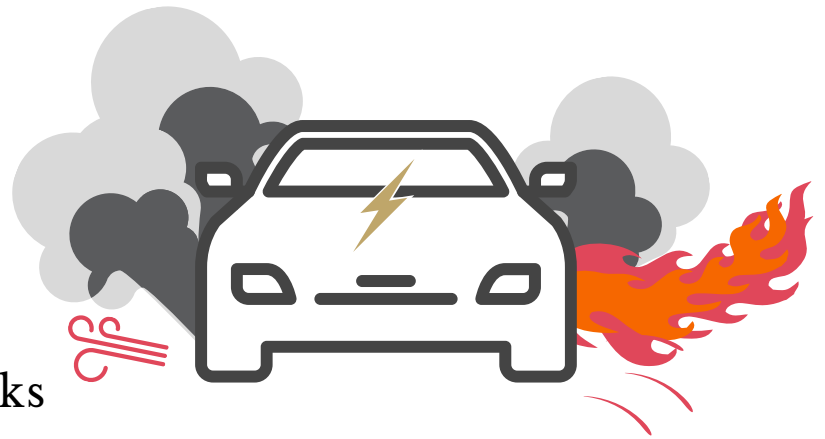
- Electrocution
- Standing in path of jet flames
- May cause thermal runaway

Space & expense

- ~ US\$65,000, limited space on fire trucks

Current & future OEM innovation

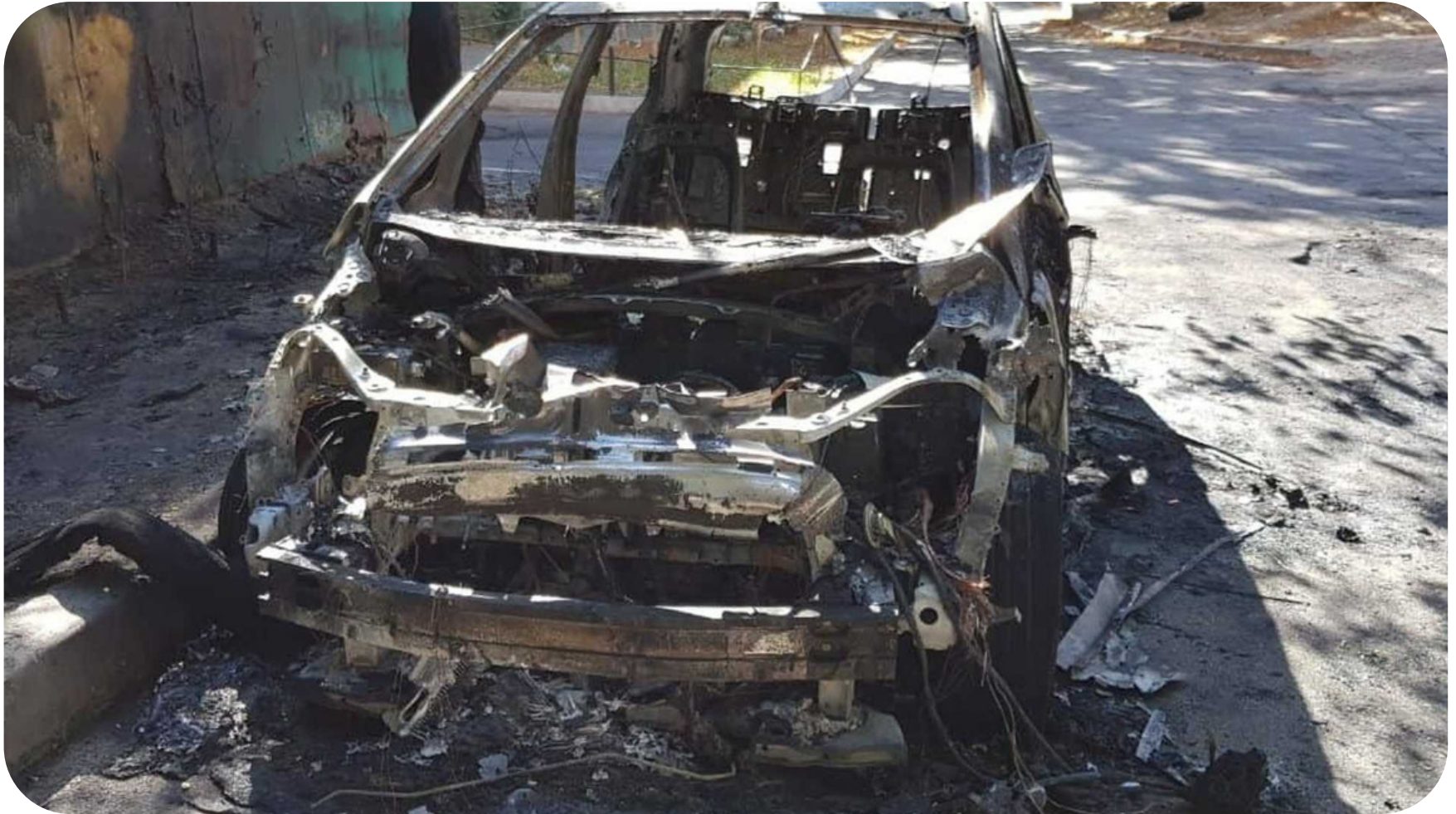
- Model 3 & Y drop out pack
- Model Y cell to pack 'glue'
- FF Access Ports in some brands



No EV manufacturer recommends cutting into a HV pack in their emergency response guides.

Many actively discourage it

Valid option...



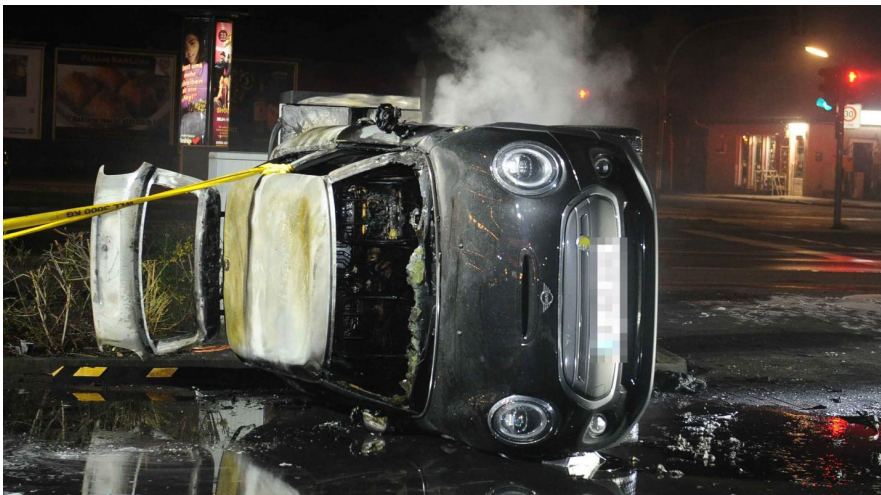
Can it burn out?



22 April 2022, Berlin, Germany

Electric Mini, possible technical defect, crews let EV burn out & flipped on side to observe

Source: spreepicture











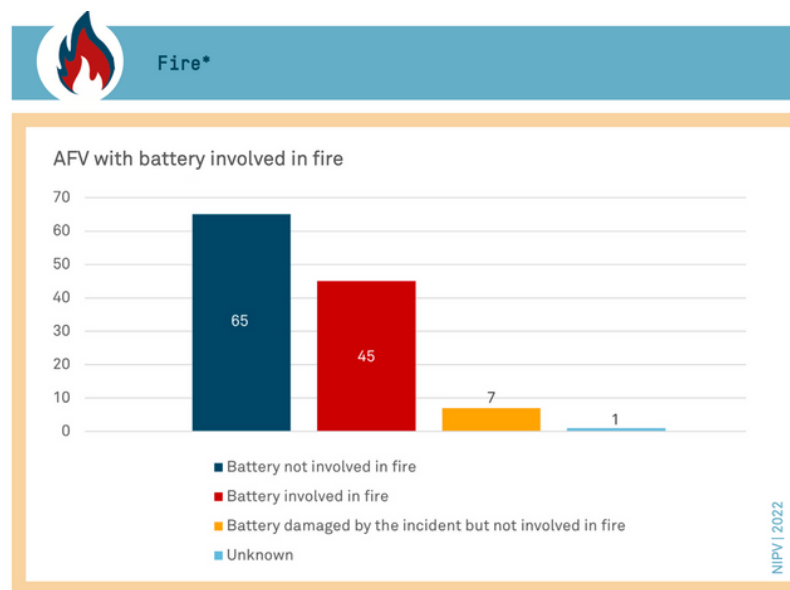
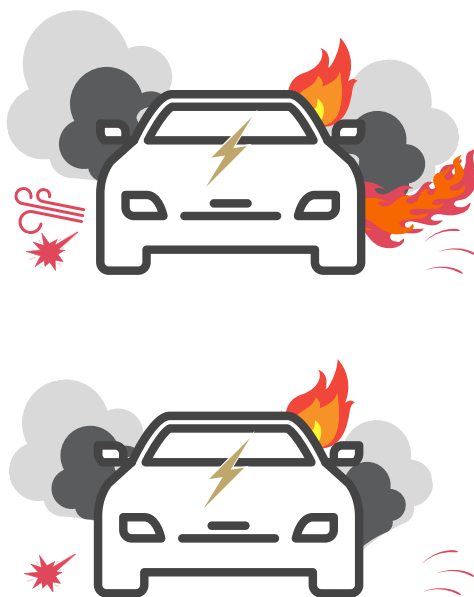




In over 50% of incidents
EV fire \neq EV battery fire

EV fires vs EV battery fires

Early data indicates less than half of electric vehicles on fire involve the high voltage lithium-ion battery



Of all 2022 EV fires in Netherlands, only **38% involved the HV battery**

NIPV (Netherlands)



FEUERWE

LHF 3200/1

F56 BEV



Fire spread - multi EVs

Early data may suggest that LiBs do not necessarily go into thermal runaway in ALL EVs during multi-EV incidents



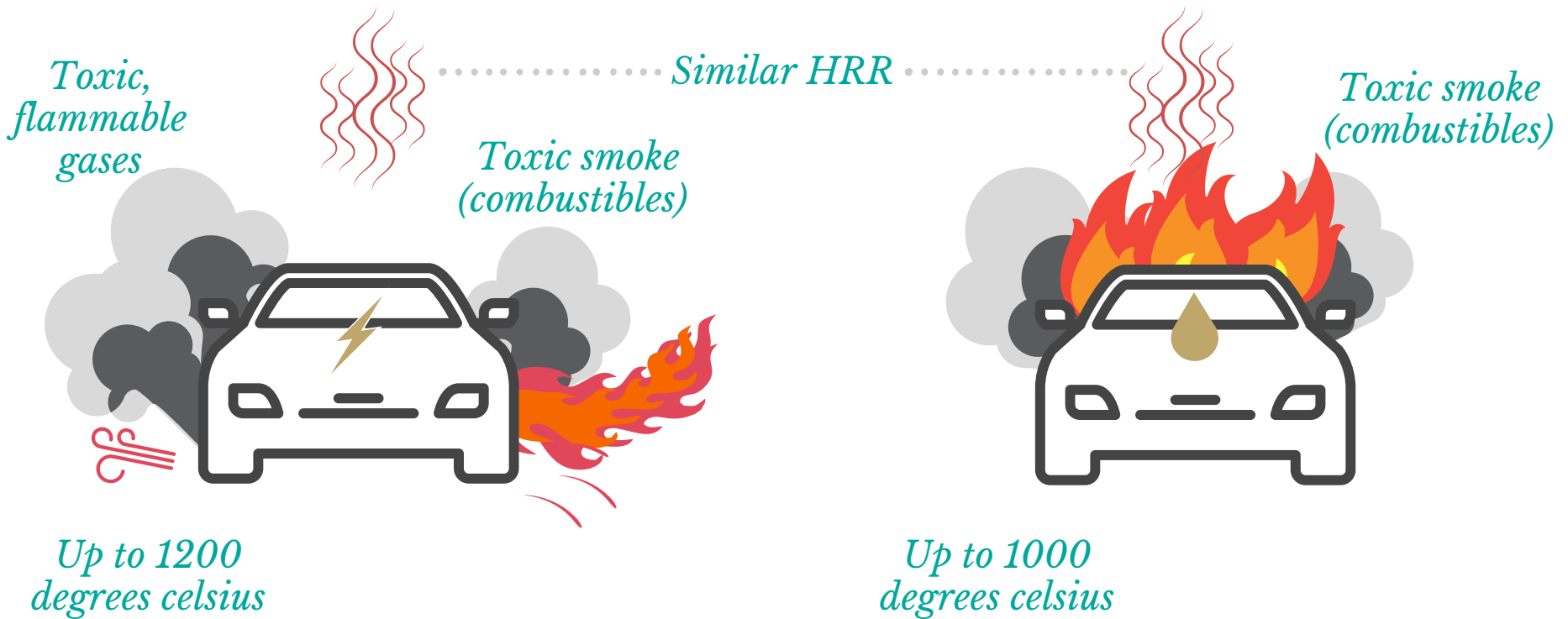


Damage to structures can be
similar to ICEV fires



EV vs ICEV: Similarities

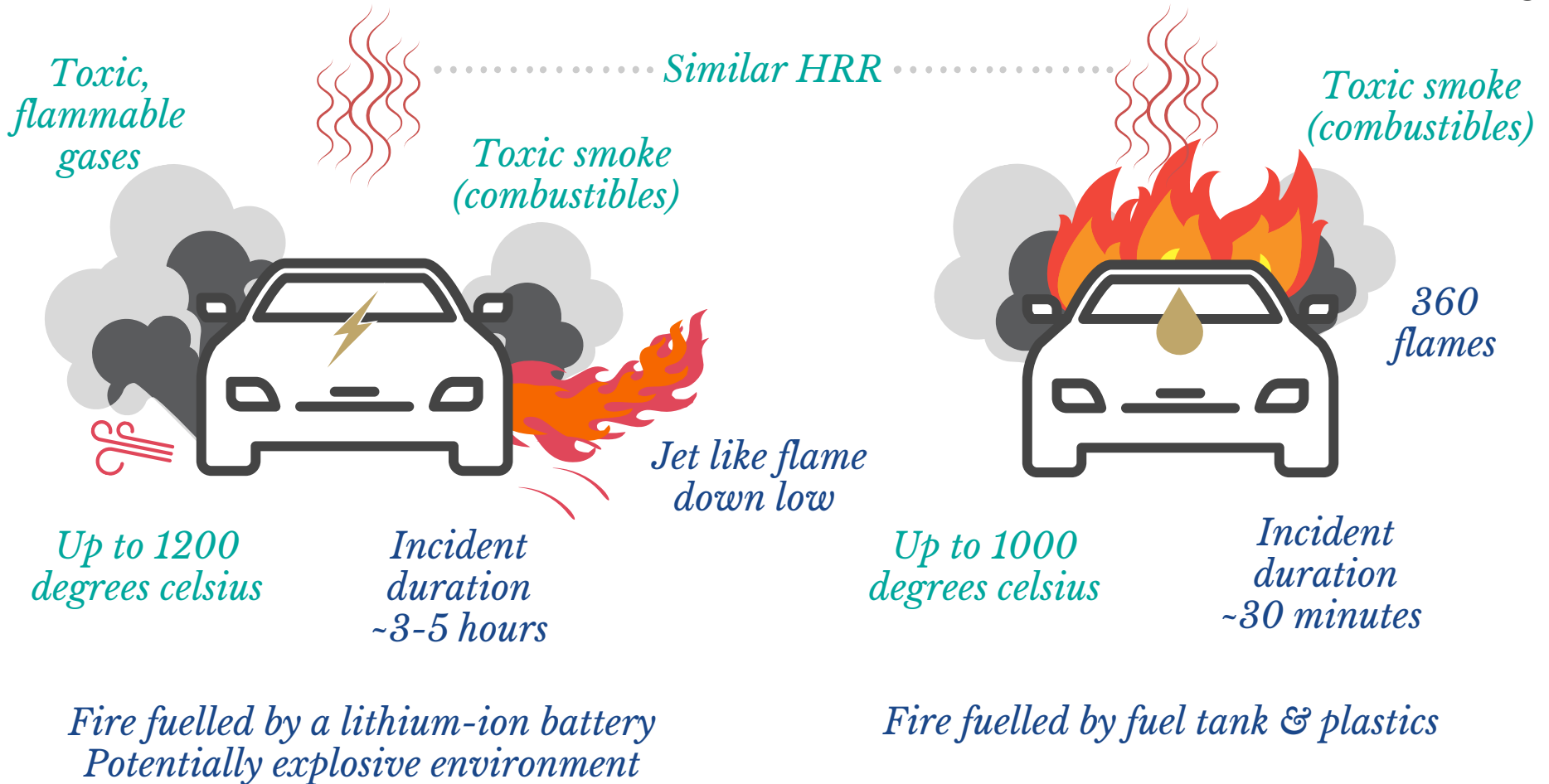
Early testing indicates similar toxicity, heat release rate (rate at which fire releases energy) & temperature between vehicle types.





EV vs ICEV; Differences

EVs have a different fuel source (HV battery vs fuel tank), incident duration & pose a secondary ignition risk.



Case study

An arson attack on an ICEV & EV in the Singel Garage in the Netherlands is the closest we have to real-world data



Citroen C3 ICEV



Hyundai Ioniq BEV



Case study

No smoke ventilation in carpark, therefore crews could not find vehicles due to lack of visibility. Little to no heat was detected & TICs could not 'see' through smoke & vapour. Carpark was manually vented by fire crews.



Ceiling spalling above
Citroen C3 ICEV



Ceiling spalling above
Hyundai Ioniq BEV





What about training & SOPs?

Very little exists...globally

Some peak bodies have published guidance, but no fire agency has released approved SOPs or training. We put a global call out & have started to collate documents on our website.

Guidance

- Institute for Public Safety (Netherlands)
- Norwegian Directorate for Civil Protection (DSB)
- Danish Emergency Management Agency
- Australian Fire Agencies Council (AFAC)
- Department of fire brigades assistance fire protection (Germany)

Training

- UL's Fire Safety Research Institute (US) - BESS
- NFPA Alternative Fuelled Vehicles Online Training for Emergency Responders (USA)
- Fire Emergency New Zealand online training
- Various FDs globally creating ad-hoc training packs & info

Published SOPs

- Fire Emergency New Zealand?
- Various FDs globally creating ad-hoc SOPs, often based on first hand experience

LiB categorisation

Depending on LiB types, emergency response may differ.
We created the following to assist departments buildings SOPs.

Smaller
Devices



Light EV
(LEVs)



Road
registered EV
(EVs)



Battery energy
storage
systems (BESS)



New category, high risk?

Road registered light electric vehicles; not quite a car, not quite an e-bike. Used for cleaning, housekeeping, small deliveries.



Emerging risk

Picnic Supermarkets use Goupil e-vans in Europe, with ~25 separate thermal runaway events in 2 years, with the total loss of 3 depot buildings



LiB categorisation - updated

Category	Smaller Devices	Light EV (LEVs)	Light delivery EV (LDEV)	Road registered EV (EVs)	Battery energy storage systems (BESS)
OEM guidance	No ERG	No ERG	No ERG	Some ERGs available	Some ERGs available
Risk	Low risk	High risk	High risk	Very low risk	Very low risk
Response	Submerge	Submerge	Cool - water on HV pack	Cool Burn Submerge	Protect exposures Burn



Training priorities (our 2 cents...)

1

EV road traffic collisions



Common
Low risk

2

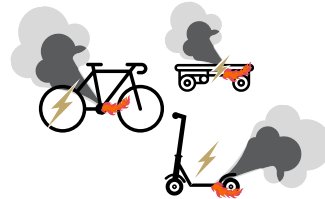
EV battery fires



Very rare
Moderate risk

3

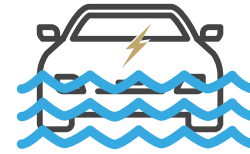
LEV battery fires



Common
Very high risk

4

EVs submerged



Uncommon
Moderate risk

5

Battery Energy Storage Systems

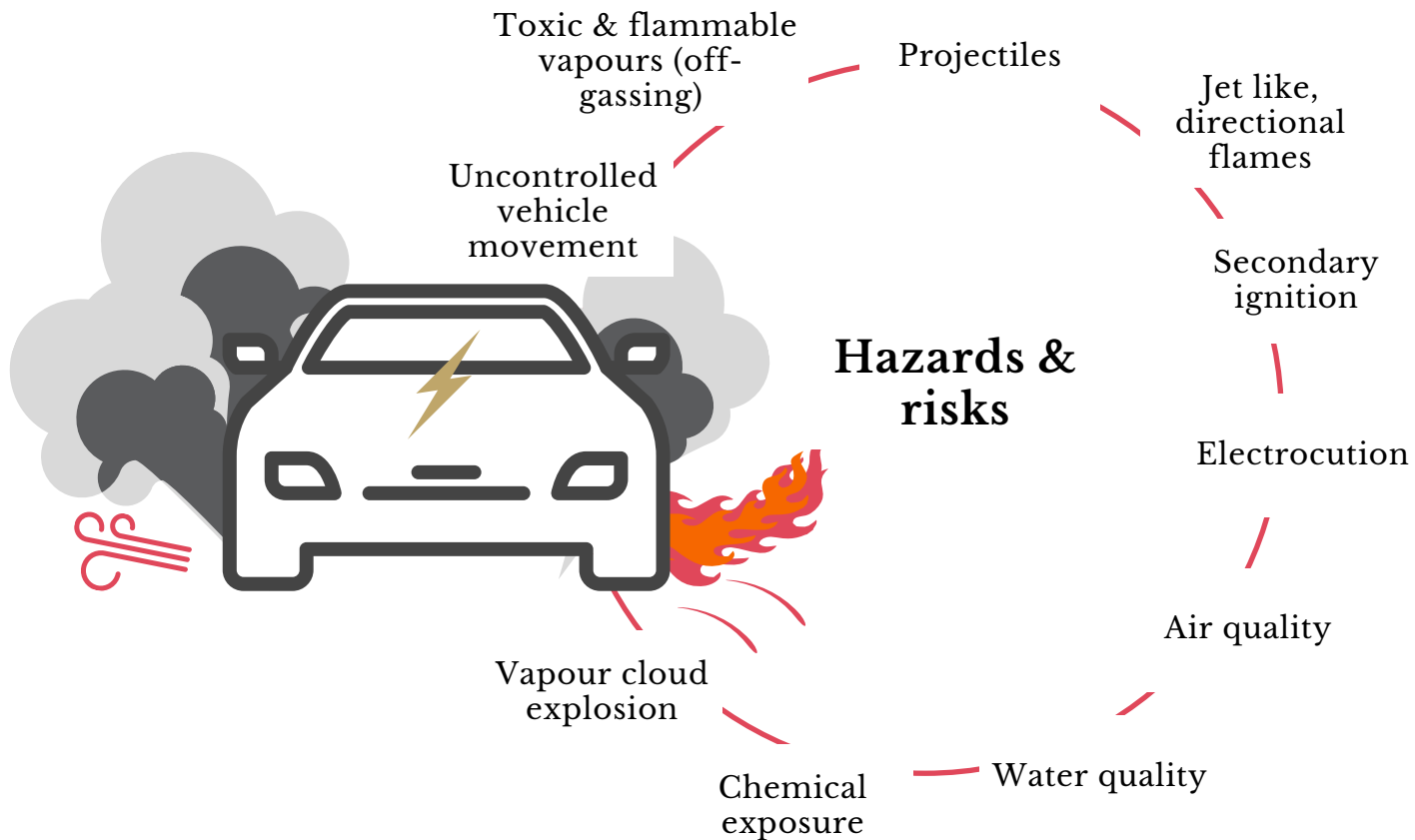


Uncommon
Moderate risk

Road traffic collisions

Frefighters & emergency responders concerns:

- New hazards & risks
- Longer incident duration
- No established methods
- No training



Identify, Immobilise, Isolate

Basis of SOPs & training in development.
Go to: evfiresafe.com/ev-extrication

Thermal runaway DRA



ERG
Approach
Exposures





EV FireSafe next steps

EV walkaround videos

Fast & informative; how to Identify, Immobilise & Isolate an EV

- We've filmed with Tesla - release mid-June
- Planning for Hyundai, Kia, MG, Polestar, Nissan & ACTFR new electric fire truck



Global webinar series

Aims to share knowledge of real-world incidents & connect responders from all countries.

12 webinars being planned:

1. EV LiB fires & emergency response
2. Where are LiBs used & what's coming?
3. LEVs & EVs - what's the difference?
4. ERGs & HV isolation
5. EV charging & emergency response
6. EV road rescue
7. EV fires - what's in the water & air?
8. Secondary & delayed ignition
9. EV Suppression - burn out or extinguish?
10. Products & tools
11. Second life batteries
12. Building SOPs

Webinar series partner (so far):



NFCC
National Fire
Chiefs Council



Anticipated reach:

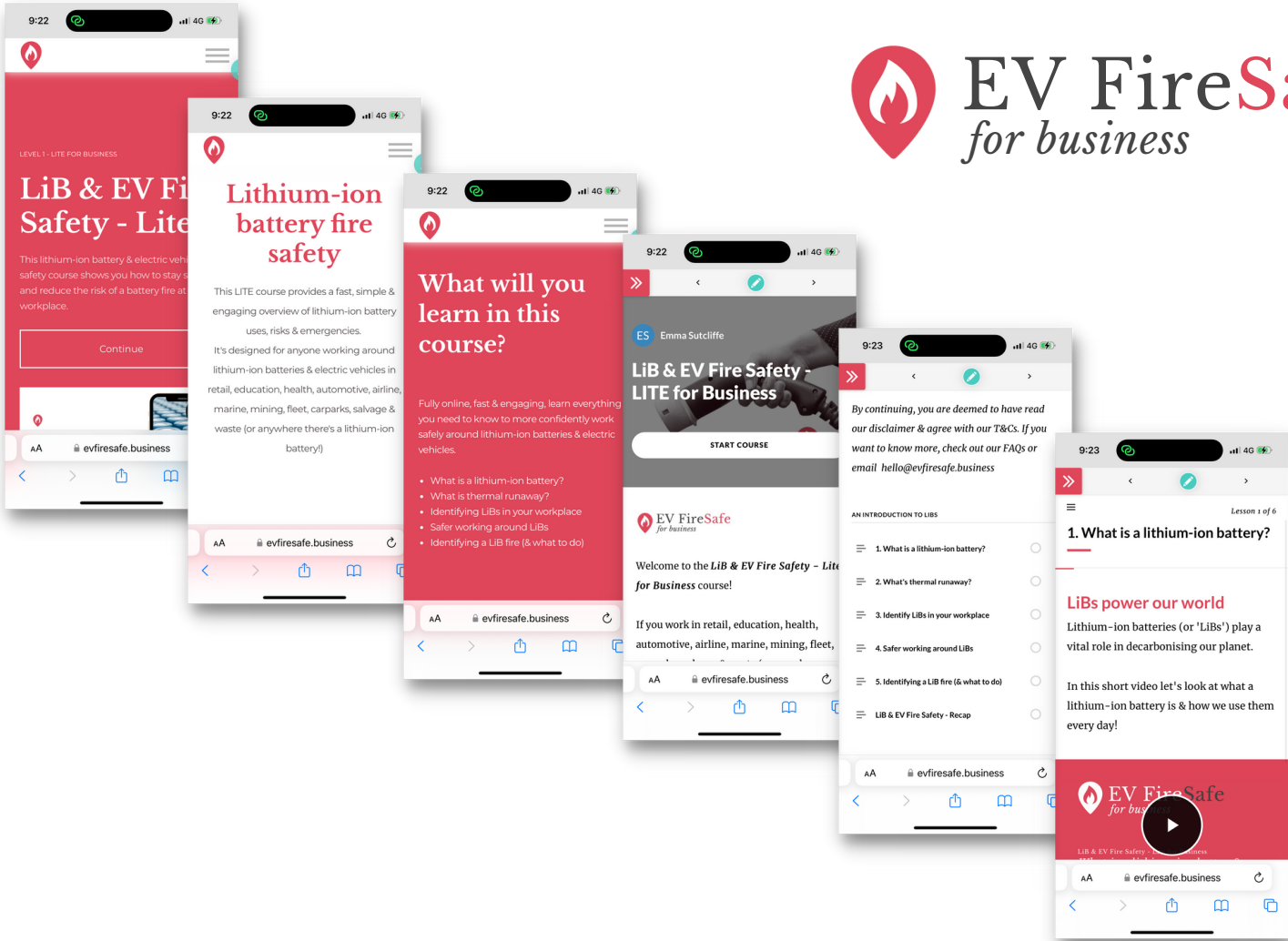
At least 32 countries

Up to 25,000 responders per webinar

Up to 1 million responders via recorded webinars on YouTube & socials

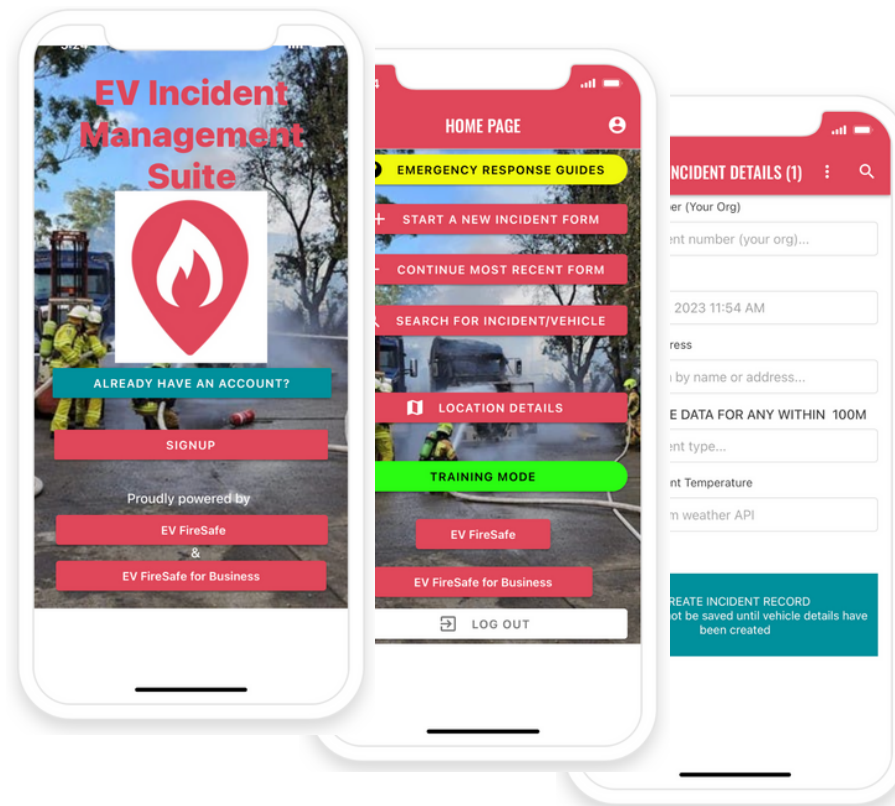
Non-emergency training

Online training for non-emergency sector



LiB TRAKA App

We're developing an app to assist first & second responders, & non-emergency businesses manage a lithium-ion battery incident or fire.



The aim is to reduce risk to all parties managing a damaged LiB, from incident to wrecking, repair or disposal.

Brand new EV charging advice

New Advisory Notice for EV charging sites from the Australian Building Code Board, released last week.

Advisory notice

Electric vehicles in buildings

To support Australians making the switch to electric vehicles (EV), the National Construction Code (NCC) is requiring more buildings to be ready for EV charging.

The global experience of EVs to date indicates they have a lower likelihood of being involved in a fire than internal combustion engines, but the characteristics of battery fires are different to liquid fuel fires.

To ensure we understand and respond proportionately to any updated evidence of EV charging risks, the ABCB has reviewed the approaches taken by international regulators including those countries with greater uptake of EVs. We have also engaged Australia research team EV FireSafe to help develop a set of recommendations that can support the safer installation and use of EV chargers without being an unreasonable barrier to adoption. The full report from EV FireSafe, on which these provisions are based, can be [read here](#).

We believe the recommendations set out in this advisory note are low cost, have minimal visual impact, are easily implementable and reflect the better practices already adopted by many reputable suppliers. These recommendations will help reduce the use of substandard equipment or installation practices emerging as the EV charging market grows.

The ABCB will continue to work with other government bodies and emergency services agencies to review the latest evidence on EV charging trends from around the world and will review and update our guidance and/or regulatory response as needed.

June 2023, Version 1.0 - © Commonwealth of Australia and States and Territories of Australia
the Australian Building Codes Board

To support safer EV charging, the ABCB recommends:

- Master isolation**: Provide a master isolation switch with signage at fire indicator panel/Fire Detection Indicator Control Equipment (FDICE) or building entrance.
- RCM Tick compliance**: Use chargers that have the Regulatory Compliance Mark (RCM).
- Emergency services information pack (ESIP)**: ESIPs developed for each site and provided for first responders.
- Break glass fire alarm**: Provide additional break glass unit (BGL).
- Placarding site**: Provide placarding/signage to identify each EV charge point.
- Collision protection**: Provide vehicle impact bollards or stops.
- Block plans**: Block plans should be updated for existing sites and implemented for new builds to clearly show the location of charging hubs and master isolation.
- AS/NZS 3000 App P compliance**: Mode 3 and 4 chargers should only be installed by a qualified person and in accordance with AS/NZS 3000 Appendix B.
- Proximity to evacuation routes and flammable risks**: Carefully assess proximity to avoid blocking evacuation routes or placing chargers too close to other flammable risks.
- Regular maintenance**: Ensure the owner of the charging unit understands and meets their maintenance obligations.
- Complex buildings**: Complex buildings and higher-risk environments should seek comprehensive, specialist fire safety assessment and advice.
- Directional signage**: Directional signage to be provided to the charging units and to the emergency exits.
- Smart charging**: Where possible, prioritise the use of "smart charging" to enable remote monitoring and access to disconnect power supply to a connected EV. This gives emergency responders another potential method of shutdown from unit to EV. Encourage operators to monitor for faults and provide early intervention when detected.
- Placarding at site entrance**: Sites with 5 or more Mode 3 or 4 chargers to install ground level or other appropriate level placards to indicate which entrance is most closely located to EV charging hub.
- Pre-incident plans (PIP)**: Where 5 or more chargers are installed, then building owners should invite local fire crews to attend a site familiarisation visit in order to develop a pre-incident plan (PIP).

The National Council for Fire and Emergency Services (AFAC) has also issued a position statement "Electric Vehicles (EV) and EV charging equipment in the built environment". Proponents of development applications that are subject to fire authority review, should familiarise themselves with the AFAC position statement and any additional advice issued by their local fire authority.

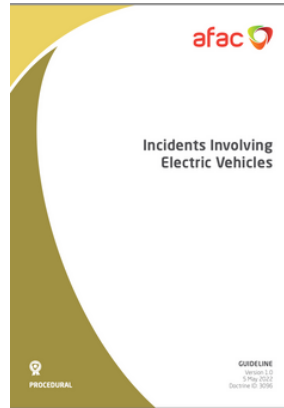
Useful (free) resources



evfiresafe.com

 @evfiresafeproject

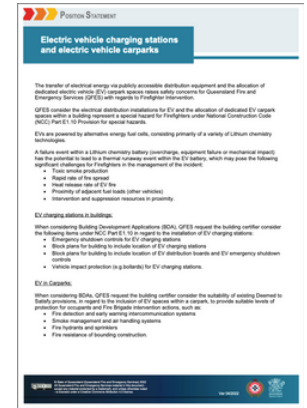
 EV FireSafe



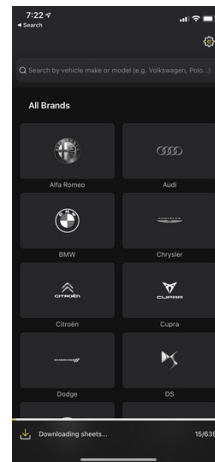
AFAC Incidents involving EVs



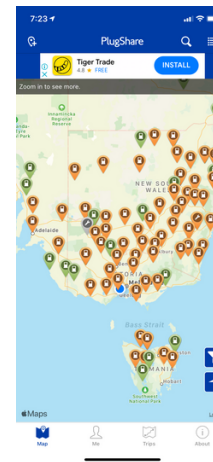
CFA Renewable Energy Facilities



QFES EV Charging in Structures



ANCAP Rescue



PlugShare app



FRNSW Battery Advice



ELECTRIC VEHICLES

Electric vehicles (EVs) are becoming more prevalent as consumers select greener transport options. EVs commonly contain lithium-ion batteries and come with associated risks and hazards (including fire and explosion, radiation, heat, chemical and electrical).

Fire and Rescue NSW is currently conducting research on how best to mitigate incidents involving these technologies and how best to respond to incidents when they occur. While we work on the research, there are some measures that we urge users to be aware of to minimise their exposure to hazards.

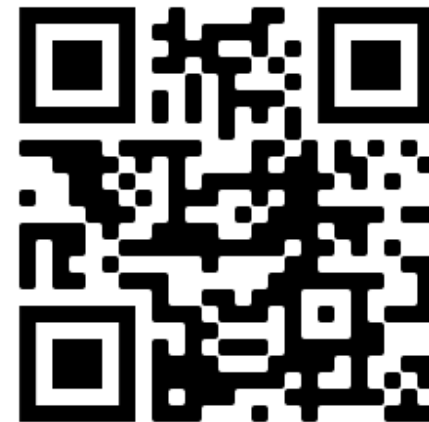
- Make sure that your EV is identifiable by emergency services. There should be a blue "EV" sticker/badge on the number plate to indicate that it is an electric or hybrid vehicle. These stickers are there specifically to



evfiresafe.com

Many thanks for your
kind attention.

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Scan with your smart
phone camera to jump
to the EVFS website

